ARCHIMEDES (A Really Cool High Impact Method for Exploring Down into Europan Subsurface)

Completed Technology Project (2016 - 2018)

Project Introduction

Subsurface exploration of ocean worlds ultimately requires significant ice penetration. We propose further development of an entirely novel ice penetrating technology, using laser light carried by an optical fiber tether and emitted from the probe's nose cone directly into the ice. This technology has critical benefits over conventional “hot point” melt probes and mechanical drills and is particularly advantageous for the extreme cold and vacuum environment on ocean worlds. Currently our direct laser probe is targeted for very efficient penetration of 1 to 10 meters depth and scales well for penetration of 10s to 100s of meters. Preliminary experiments conducted at Stone Aerospace over a range of power levels and ice penetration rates produced excellent results exceeding expectations (TRL 3) and achieving the fastest recorded cryobot descent speed to date. We propose to develop, build, and characterize a direct-laser-based penetrator system, refining and advancing this technology to TRL 5. We will test a range of probe diameters and laser power levels under relevant extra-terrestrial environmental conditions. Additionally, we will investigate fiber-coupled optical biomarker sensors that take advantage of the laser's fiber optic tether. Conventional hot point melt probes tested under vacuum have shown extreme difficulty initiating penetration (Kaufmann, et al. 2009), as there is virtually no thermal contact between the probe nose and rough ice surface. The ice simply sublimates and any transferred heat is quickly dissipated due to the low power density and extreme cold. With direct laser heating, no thermal contact is needed, and 100% of the laser power is deposited directly into the ice with no thermal handling losses. Furthermore, 1070 nm radiation has greater absorption in ice than in water, which limits attenuation through any water pocket in front of the probe. Higher power densities and faster cryobot penetration times are now made possible, which is critical because probe efficiency climbs dramatically at higher speeds by avoiding extreme conductive losses in cold ice. A major benefit of depositing energy into a volume of ice, rather than upon a surface, is a lower resulting temperature for sampling compared to hot point probes, which must generate large temperature gradients to force the heat through layers of ice and water. During proof of concept testing, we observed only moderate temperature rises at the ice-water interface, implying that samples will not be excessively heated. Another advantage to this laser approach is that the probe's fiber optic tether, along with a dedicated sensor fiber, enable a form of "optical access" to the subsurface environment. This access can be utilized by a lander's on-board instruments (Raman Spectrometer, etc.) or instruments dedicated to the penetrator (fiber spectrometer, EM sensor for light spectrum, etc). These sensors can search for biomarkers and characterize the radiation/light environment for subsurface habitability, including photosynthetic potential and radiation environment as a source for energy and damage. This combination—laser penetrator and integrated fiber instruments—could be a powerful new lightweight tool for an ocean world lander. Technical objectives of this project are: 1. Develop and build a direct-laser penetrator 2. Test and characterize

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

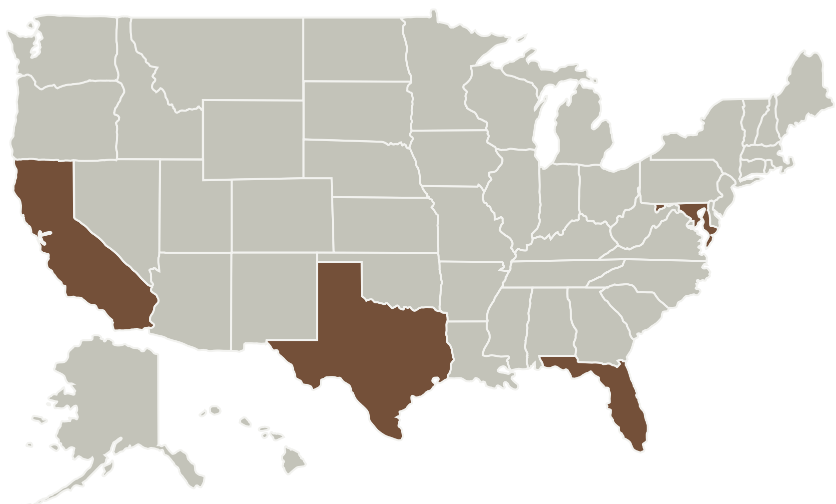
Responsible Program:

Concepts for Ocean Worlds Life Detection Technology the penetrator in ice under vacuum and at 100K temperature, over a range of penetrator diameters. 3. Investigate fiber-coupled optical sensing strategies, including both pairing the fiber with potential on-board instruments as well an in-situ demonstration of integrated spectrographic and EM instruments. Co-I Hogan will lead direct laser melting development and cryobot design. Co-I Bramall, a life-detection instrument designer, will manage fiber sensing and spectroscopy instrument development and integration. Co-I Christner will serve as microbiology advisor.

Anticipated Benefits

The results of this project will be used by NASA's Europa Lander and subsequent Ocean Worlds and Mars polar landers to penetrate and characterize icy crusts in the search for extraterrestrial life.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Piedra - Sombra Corporation, Inc.	Supporting Organization	Industry	

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

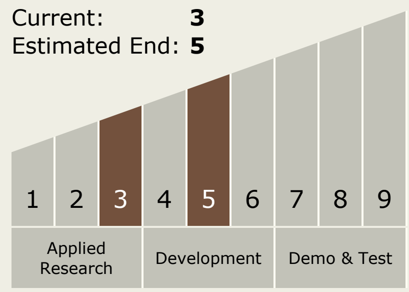
Carolyn R Mercer

Co-Investigators:

William C Stone
Carol R Stoker
Nathan E Bramall
Brent C Christner
Bartholoomew Hogan

Technology Maturity (TRL)

Start: **3**
Current: **3**
Estimated End: **5**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.3 In-Situ Instruments and Sensors
    └ TX08.3.4 Environment Sensors

Primary U.S. Work Locations	
California	Florida
Maryland	Texas

Target Destination

Others Inside the Solar System